Space Weather Technical Forecast

Issued on Wednesday, 19 April 2023 at 01:13 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: G1/Minor Storms likely due to CME activity, with a chance of G2/Moderate or G3/Strong Storms on 20 and 21 April. Chance of M-class flares (R1-R2 Minor-Moderate radio blackouts) throughout.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been Low with a number of C-class flares observed and peaking at C4.8 from AR3280 at 18/1529TC. AR3280 rotated across the western limb during 17 April. There are seven active regions on the visible disc. The largest region is AR3282 in the northern hemisphere near centre disc. This area has a large longitudinal extent with few spots between the large leader and trailer spot. A succession of sunspot groups persists around 20S latitude with AR3279, followed by AR3281 and then AR3283. The regions are relatively simple and stable, although appear to be interacting magnetically. AR3284 near the eastern limb also appears magnetically simple. The remaining regions are small and simple. No Earth-directed CMEs have been observed in available imagery during the last 24 hours.

Solar Wind / Geomagnetic Activity: The solar wind observed at L1 was slightly elevated to start the period before a change to elevated levels in response to a CME arrival around 18/1400UTC, with a peak of 623 km/s observed at 18/2033UTC. Density was at below average levels before becoming above average from around 18/1400UTC with a peak of 33ppcc observed at 18/1637UTC. Total magnetic field strength was at weak to moderate levels, before becoming strong for a few hours after 18/1400UTC. The important north-south component was also at weak to moderate levels with a period of negative orientation observed around 18/1600UTC as strong levels were reached, with a peak of -17 nT recorded at 18/1549UTC. The phi angle was positive (away from the sun) before a switch to negative (towards the sun) as the CME arrived. Geomagnetic activity was Quiet.to Unsettled (Kp0-3) becoming Active (Kp4) by 18/1500UTC, with a period of G1/minor geomagnetic storms (Kp5) from 18/1500-1800UTC.

Energetic Particles / Solar Radiation: High energy proton flux (greater than 10MeV) as measured at GOES16, was at background levels. High energy electron flux (greater than 2MeV) as measured at GOES16 was at background to moderate levels. The associated 24-hour integrated electron fluence was well below the Active threshold on a steady trend, with 1.52e6 integrated pfu observed at 19/0000UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity is expected to be generally Low, with a likelihood of isolated Moderate activity, mainly due to AR3282. There is also a chance for activity from a region beyond the northeastern limb, which is forecast to rotate onto the visible disc by day 2 (20 Apr).

Solar Wind / Geomagnetic Activity: Two CMEs may affect the Earth in this period. The first carries low confidence for a glancing blow on day 1 (19 Apr), with a further more direct CME hit, forecast on days 2 or 3 (20 or 21 Apr). Otherwise solar winds are expected to become slightly

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elevated with an initial period more predominantly at elevated levels as a result of the CME that impacted the Earth on 18 April. Geomagnetic activity is forecast to be Unsettled to Active with further Minor storm intervals, especially due to the potential glancing CME on 19 Apr. Activity is expected to reach G1/Minor Storm levels on 20 or 21 Apr due to the anticipated second CME arrival, with a chance of G2/Moderate or G3/Strong Storm conditions.

Energetic Particles / Solar Radiation: High energy (greater than 10MeV) proton flux is most likely to persist at background levels, although there is a very slight chance of a S1 or greater event. High energy (greater than 2 MeV) electron flux is currently at background to moderate levels with little change probable throughout much of the period. The associated 24-hour integrated fluence is expected to remain below the Active threshold (1e8 integrated pfu).

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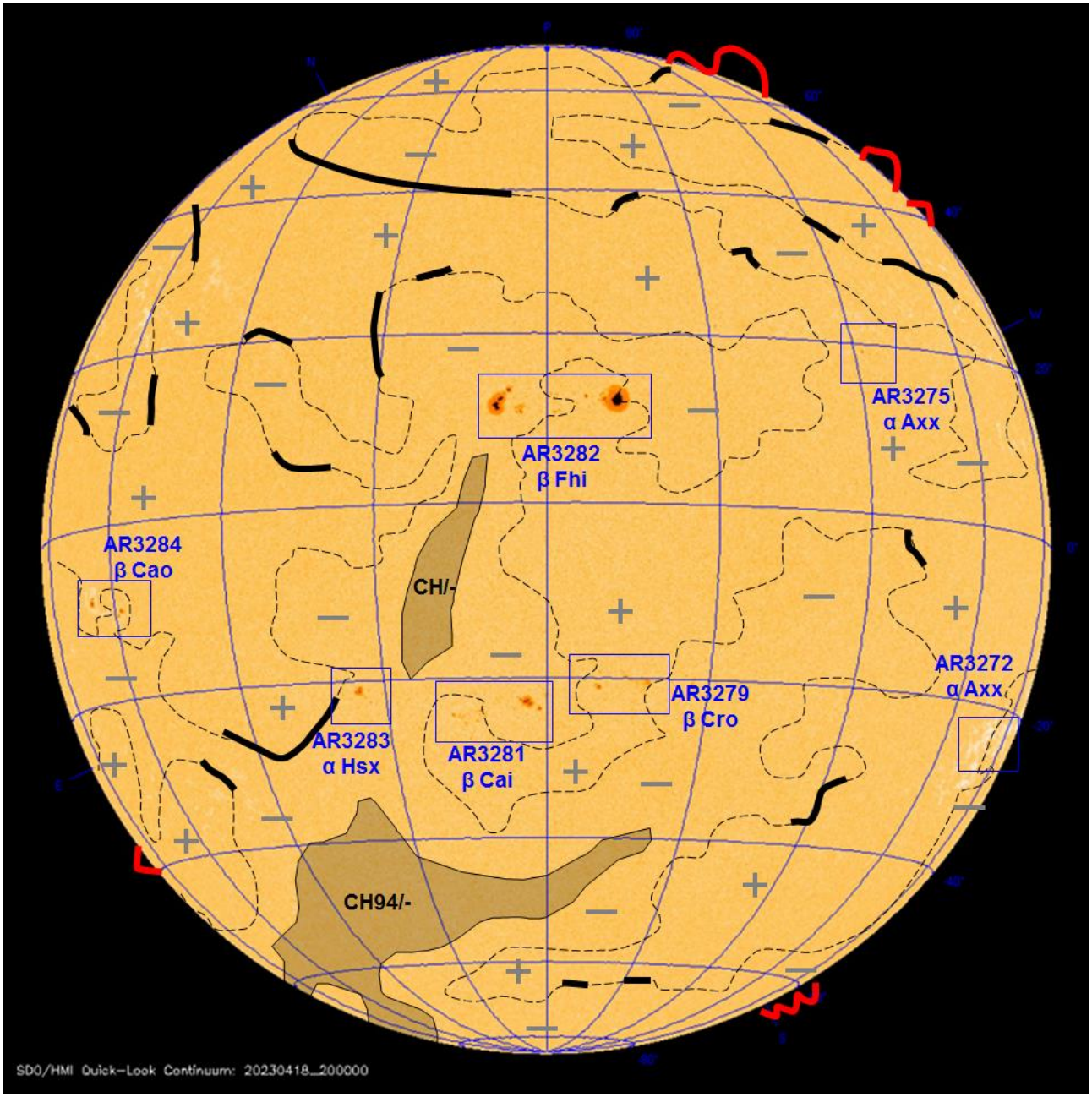
Figure 1. Solar Analysis Valid 2000UTC, 18 April 2023.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

A couple of CMEs have been analysed with the potential to affect Earth during the forecast period. The first, a filament eruption at around 15/1100UTC is forecast to potentially glance the Earth during day 1 (19 Apr), but the majority if not all of the CME is expected to pass behind Earth-orbit. A faint CME halo from a large filament eruption later that same day (15/2324UTC) is more likely to affect Earth, arriving on either day 2 or 3 (20 or 21 Apr). Confidence in the arrival time and geomagnetic effects is only moderate given the apparent diffuse signature of the CME in LASCO C2 and C3 imagery and limited STEREO A data for the event. A broad expected arrival window from early on 20 Apr until the end of 21 Apr is the most likely arrival time of the CME.

Earth is currently in an elevated to strong solar wind regime following the impact of the CME on 18 April. Solar winds have probably peaked with a decline back to slightly elevated probable ahead of the CME arrivals in the coming days 1 to 3 (19-21 Apr). The next CH high-speed stream is not expected to become geo-effective until around 23 Apr, although given the high southern latitude of the feature, any connection carries rather low confidence.

Geomagnetic activity is forecast to be Unsettled to Active (Kp3-4) with further G1/Minor storm intervals (Kp5), especially due to the potential glancing CME on 19 Apr. Activity is expected to reach G1/Minor Storm levels (Kp5) on 20 or 21 Apr due to the anticipated second CME arrival, with a chance of G2/Moderate (Kp6) or G3/Strong Storm (Kp7) conditions.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	50	60	60	30
Strong	G3	No	10	30	30	10
Severe	G4	No	1	5	5	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
16/0550	Partial	Filament eruption	NW	250 km/s	19/1200UTC +/- 9 hrs	Low confidence
16/1343	Full	Filament eruption	NW	342 km/s	20/1300UTC +/-12hrs	Possible G2/G3 storms. Low confidence

Figure 2: Latest ENLIL output, including ensemble guidance, with large temporal spread for arrival time of the second CME.

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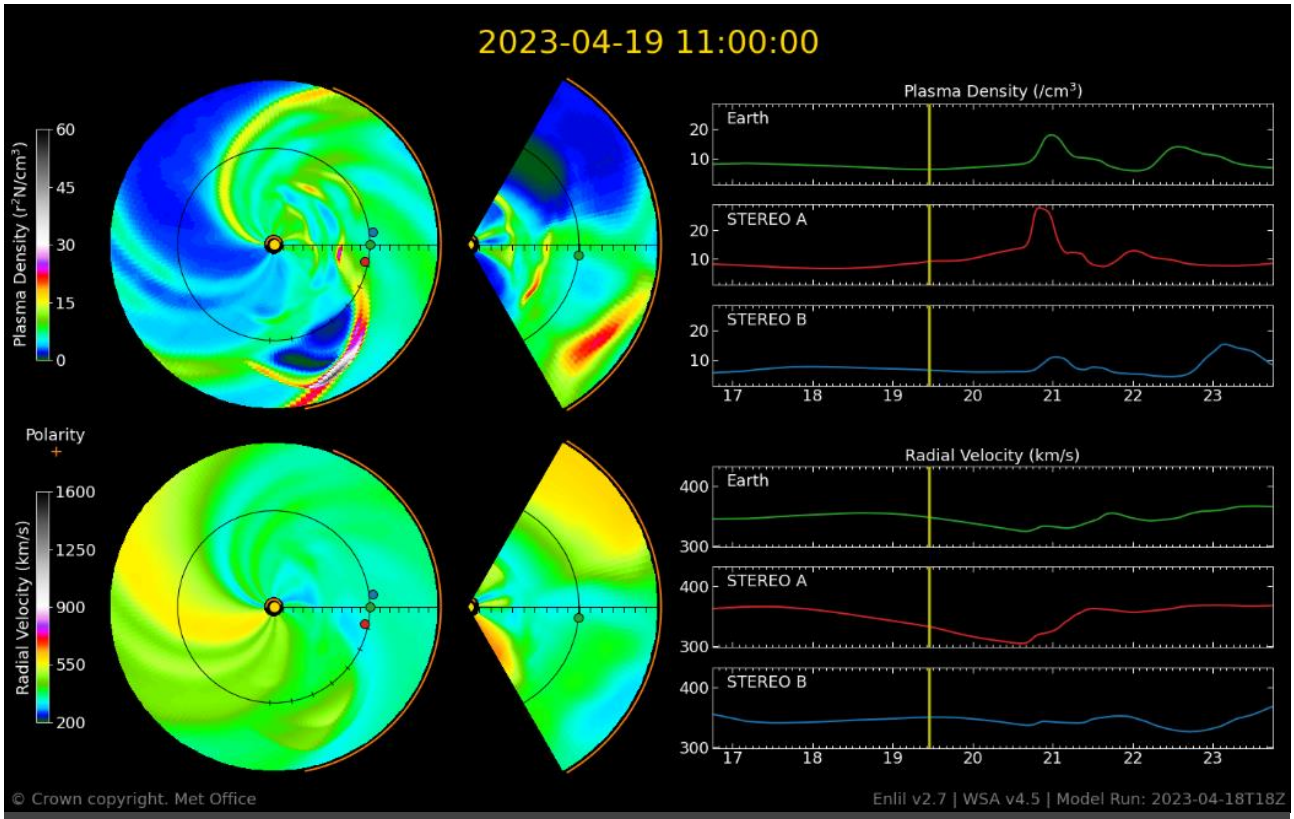

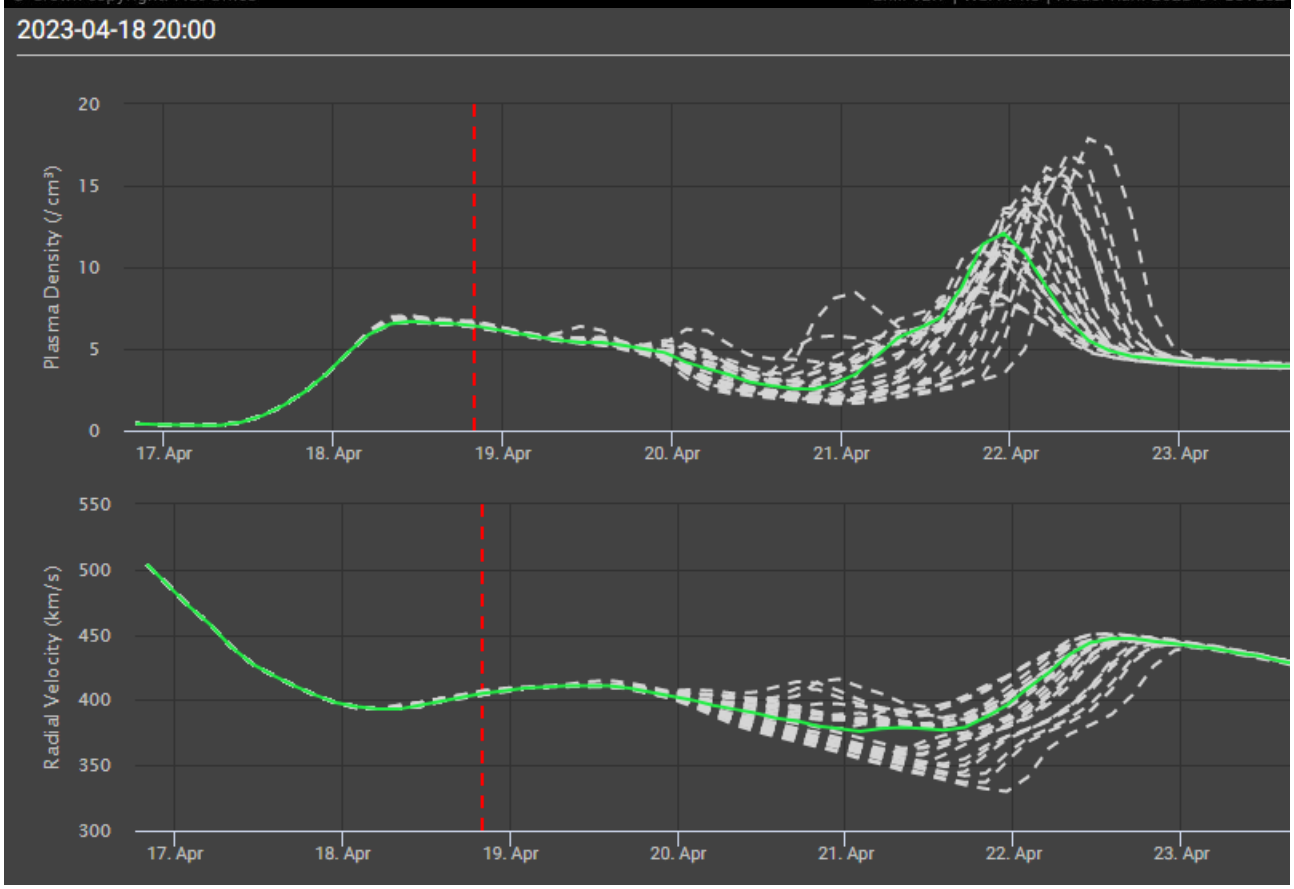

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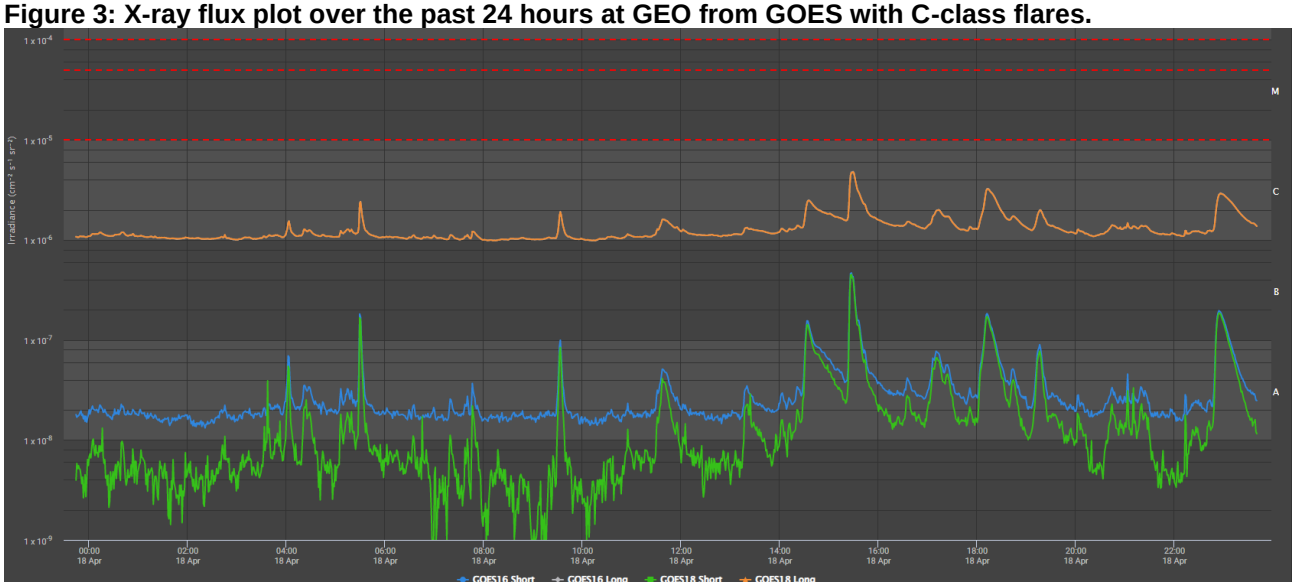
Radio Blackouts - X-Ray Flares:
There are seven active regions on the visible disc, AR3282 is the largest and most prominent region. In general there has been little change in the appearance of the group and has been generally inactive with a large longitudinal extent. There continue to be some minor reorganisation of small intermediate spots and this region poses the greatest risk for significant flares at present. A succession of sunspot groups persists around 20S latitude with AR3279, followed by AR3281 and then AR3283. The regions are relatively simple and stable, although appear to be interacting magnetically. AR3284 near the eastern limb has shown some slight growth in leader and trailer spots, though also appears magnetically simple at present. All other regions are small and simple. A new region beyond the northeast limb appears bright on SDO AIA 94 imagery and could reveal a sunspot group as it rotates onto the visible disc by day 2 (20 Apr). The position of the group would match up with Ex-AR3264 from the previous rotation. Low solar activity is predicted in general, with a likelihood of isolated M-class flares and a very slight chance of X-class flaring during the guidance period.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	No	40	40	50	50
Very Active	R3 to R5 X Class	No	1	1	5	5

Figure 3: X-ray flux plot over the past 24 hours at GEO from GOES with C-class flares.



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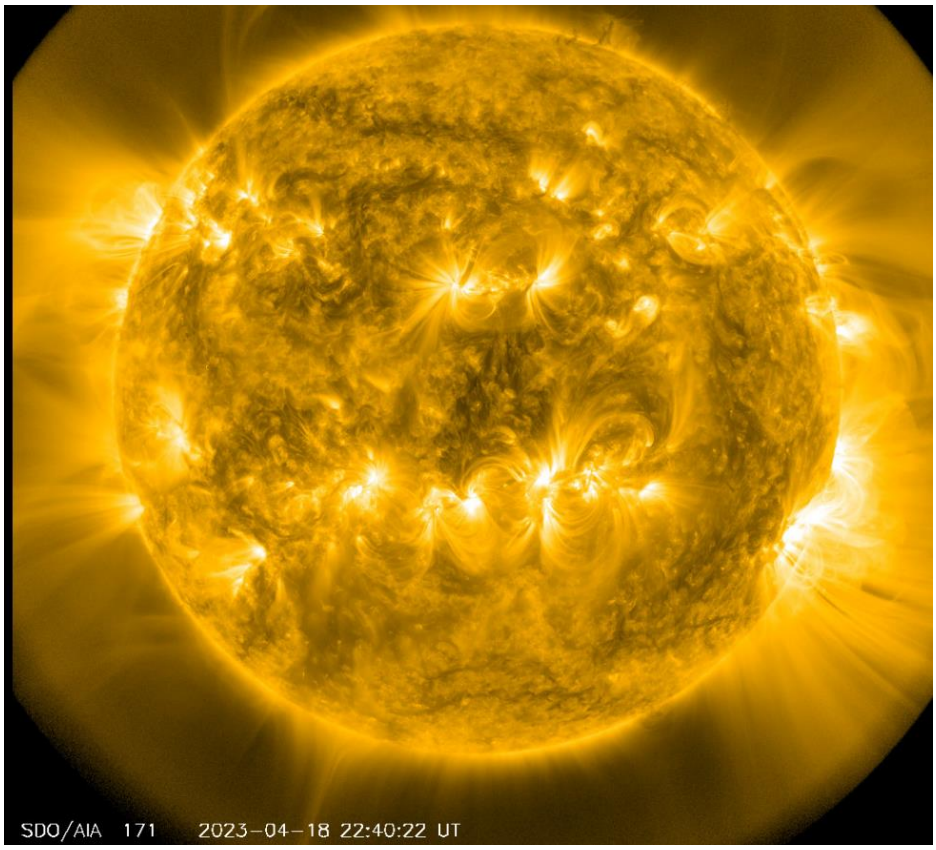
Solar Radiation Storms - (High Energy Protons):
High energy proton flux (greater than 10MeV), as observed by GOES16, is most likely to remain at background levels through the period. AR3280 which rotated over the western limb during 17 April, carries the greatest initial risk of a proton event.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	≥ S1	No	5	1	1	1
Very Active	≥ S3 *	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 4: SDO-aia 171 imagery giving an indication of latest activity on visible disc.



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High Energy Electrons Event (≥ 2MeV):
As a result of the current elevated solar wind regime affecting Earth this may feed electrons into the radiation belts, combined with solar wind pressure to expand the belts into increased orbits therefore resulting in the high energy electron flux (greater than 2MeV) reaching moderate, possibly high levels on days 1 and 2 (19 and 20 Apr). Enhanced geomagnetic activity due to forecast CME arrivals between 19-21 Apr could then lead to a resumed depression, with a gradual increase most likely beyond the end of the forecast period as the geomagnetic activity fades.
Electron fluence is expected to remain below the Active threshold due to the forecast geomagnetic enhancements.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	1	1	1	1
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

Figure 5: High energy electron flux at GEO and Met Office REFM output.

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